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贵州中三叠世早期幻龙属(*Nothosaurus*)一新种[1)]

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摘要:作为三叠纪海生爬行动物的重要分子,幻龙属化石主要发现于欧洲、中东和中国西南地区的中三叠世海相地层,且主要集中分布于安尼期晚期和拉丁期晚期(Edinger, 1921; Haas, 1980; Rieppel, 2000)。我国目前已报道的幻龙属化石有两种:杨氏幻龙(Li and Rieppel, 2004)和幻龙属未定种(Rieppel, 1998),它们均产于贵州省兴义地区的法郎组竹杆坡段,时代为中三叠世拉丁期。最近在贵州省盘县地区关岭组II段地层中也发现了数量较多的幻龙骨骼化石,证明中三叠世早期东特提斯区同样生存着幻龙类。鉴于标本的骨骼特征与已知的幻龙属种相比存在一定的差异,因此本文建立一新种 *Nothosaurus rostellatus* sp. nov.(小吻幻龙)。

新种的个体在幻龙属种中为中等(头骨中线长210～320 mm);吻部短而小,具4个前颌骨獠齿,紧随其后是第5个明显较小的前颌齿;一对上颌骨犬齿之前有6～9个小型上颌齿;眼窝较大,卵圆形,位置相对靠前;内鼻孔的后缘由腭骨构成,具内鼻槽;外翼骨形成腹向凸缘;下颌具冠状突;背椎神经棘较低,背肋肩部明显加厚。*N. rostellatus* 与其他已知种的主要区别特征是吻部形态和比例。新种的吻部较小,长略大于宽,前端钝圆,基部明显收缩,其吻部长度(从吻端至外鼻孔前端的距离)仅占其头骨中线长度的1/6～1/7,而其他种一般占1/4～1/5,具有细长吻部的 *N. haasi* 甚至接近1/3。此外,新种吻端-上颞孔前缘距离与吻端-外鼻孔前缘距离的比值也明显高于其他种。*N. rostellatus* 区别于其他幻龙种的另一主要特征是上颌骨牙齿的数目和排列。在已知的幻龙属种中,很少有一对上颌犬齿前的上颌齿数超过5个者。新种正型标本 IVPP V 14294 在一对上颌犬齿前具有6个小型锥状上颌齿,它们大小相等,指向腹方。副型标本 IVPP V 14301 在一对上颌犬齿前具有9个小型锥状上颌齿。

在已知的 *Nothosaurus* 中,新种与 *N. youngi* Li & Rieppel, 2004 和 *N. marchicus* Koken, 1893 无论是个体大小还是头骨形态均比较接近,如具有相对短而宽的吻部和较短的上颌齿列、相似的鼻骨形态等,与其他种相差较大,因此这里仅对新种与此二种之间的异同做简要的介绍。从头骨的一些具体形态特征看,*N. rostellatus* 的鼻骨后侧方与前额骨相连,阻隔了额骨和上颌骨,该特征与 *N. youngi* 相同而不同于 *N. marchicus*,后者鼻骨受额骨与上颌骨的阻隔,不与前额骨相连。如果不考虑鳞骨的外侧分支的宽度,V 14294 和 V 14301 与 *N. youngi* 的头骨的最宽处均位于轭骨的后端位置,且其宽度为吻部宽度的2.6～3.5倍(其中 *N. youngi* 为2.6倍,V 14294 为3倍,V 14301 为3.5倍),而 *N. marchicus* 的最宽处位于头骨后部鳞骨的分支处,其轭骨后缘处头骨宽度为吻部宽度的2～2.8倍(Rieppel and Wild, 1996, fig. 36, 41)。此外,*N. rostellatus* 外翼骨形成腹向突起和下颌具冠状突的特点也与 *N. youngi* 相同,*N. marchicus* 不具有该特征。另一方面,*N. rostellatus* 的枕部特征则与 *N. marchicus* 接近而不

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同于 *N. youngi* 。新种的枕部内凹,枕骨侧边的后耳骨等向后侧部延伸,下颌关节在头骨后部位于枕髁之后,该枕部特征与 *N. marchicus* 一致。*N. youngi* 的下颌关节与枕髁基本位于一个平面内,因此枕部未形成明显的内凹。新种的眼眶与上颞孔之间的距离相对较宽,其中 V 14294 眼眶与上颞孔之间的距离与外鼻孔与眼眶之间的距离接近相等,而 V 14301 眼眶与上颞孔之间的距离大于外鼻孔与眼眶之间的距离。此特征也与 *N. marchicus* 相同而不同于 *N. youngi* ,前者眼眶与上颞孔之间的距离与外鼻孔与眼眶之间的距离相等,后者的眶后弓很窄,其眼眶与上颞孔之间的距离小于外鼻孔与眼眶之间的距离的 1/2。*N. rostellatus* 鼻骨的左右两前突分别伸至两外鼻孔的前缘内侧,位置与 *N. marchicus* 相同,而 *N. youngi* 鼻骨前突仅伸至外鼻孔内侧缘的中部。*N. rostellatus* 前颌骨的背突向后伸至外鼻孔后缘之后,接近鼻骨的后缘,而 *N. youngi* 仅伸至外鼻孔后缘中间部位。除前文所述新种两个主要鉴定特征外,*N. rostellatus* 又以具有内鼻槽,翼骨前伸至内鼻槽附近等特征与该已知二种相区别。此外,新种前颌骨具外侧支突起,其他种该特征多不明显,如 *N. jagisteus* 不存在前颌骨外侧支突起,其前颌骨在外鼻孔的前外侧缘沿前外侧方向与上颌骨相交(Rieppel, 2001)。从地理分布和地层层位看,*N. marchicus* 主要分布于欧洲中部的中三叠统安尼阶,而 *N. youngi* 则分布于我国贵州南部的中三叠统拉丁阶。本文描述的化石产于贵州南部关岭组 II 段,其时代应相当于中三叠世晚安尼期。*N. rostellatus* 与分布于欧洲的同时期的幻龙 *N. marchicus* 以及与在其后约 7 ~ 8 Ma 相邻地区出现的 *N. youngi* 的亲缘关系的远近可能还需要更深入的研究来证实。

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A NEW SPECIES OF *NOTHOSAURUS* FROM THE EARLY MIDDLE TRIASSIC OF GUIZHOU, CHINA

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Abstract A new species of *Nothosaurus*, *N. rostellatus*, is described from the early Middle Triassic Guanling Formation (Member II) in Panxian County, Guizhou Province, China. It is a medium sized species and characterized by relatively small rostrum, more than six precanine maxillary teeth, developed ectopterygoid flanges, dstinct pachyostotic "shoulder" part of dorsal ribs. It represents the first record of Anisian *Nothosaurus* in the Eastern Tethyian faunal province.

Key words Panxian, Guizhou, Middle Triassic, Nothosauridae

Nothosaurus is a genus of marine stem-group sauropterygian reptiles which attained a widespread distribution in near shore marine habitats during the Middle and early Late Triassic. Most species of this genus are known from late Anisian and late Ladinian sediments (Rieppel, 2000). Up to now, two species, *Nothosaurus youngi* (Li and Rieppel, 2004) and *Nothosaurus* sp. (Rieppel, 1998), were reported from southern China. They all come from the Zhuganpo Member of the Falang Formation in Xingyi area, Guizhou Province, and are considered to be of late Ladinian age (Li and Rieppel, 2004). In this paper, I present new *Nothosaurus* materials from Member II of Guanling Formation of Panxian area, Guizhou Province. This member is generally considered to be of Middle Triassic late Anisian age (GBGMR, 1987). Detailed anatomical information of these skeletons leads me to identify a new species after comparison with previously described species. According present understanding, it is the first discovery of Anisian *Nothosaurus* in the eastern Tethyian faunal province.

Sauropterygia Owen, 1860

Nothosauria Seeley, 1882

Nothosauridae Baur, 1889

***Nothosaurus* Münster, 1834**

***Nothosaurus rostellatus* sp. nov.**

(Figs. 1 ~ 3)

Etymology From rostell- (Latin), meaning "small rostrum".

Holotype A complete skull, incomplete lower jaw and postcranial skeleton (Institute of Vertebrate Paleontology and Paleoanthropology, IVPP V 14294).

Paratype A nearly complete skull and incomplete postcranial skeleton, but dorsoventrally extremely compressed (IVPP V 14301).

Locality and horizon Panxian, Guizhou Province, southern China; Member II of Guanling Formation, Anisian, Middle Triassic.

Diagnosis A species of *Nothosaurus* of medium overall size (the condylobasal skull length 210 ~ 320 mm); rostrum relatively short and small; five fangs on each premaxilla, the fifth slightly smaller; 6 ~ 9 small maxillary teeth preceding the paired maxillary fangs; orbits relatively large and oval, positioned relatively forward on the skull; palatine forming the posterior margin of the internal naris, with distinct choanal groove; ectopterygoid flanges at the anterior margin of the subtemporal fossa developed; lower jaw bearing a distinct coronoid process; short neural spines on dorsal and caudal vertebrae; distinct pachyostotic "shoulder" part of dorsal ribs.

Comments The species here described is known from two incomplete skeletons, but the skulls are well preserved. The axial skeleton of the holotype is partially articulated, exposed for nearly 1 meter in length, including the posterior cervical parts, dorsal parts, sacral parts, anterior caudal parts of the vertebral column, dorsal, gastral, sacral, and partly caudal ribs, and incomplete pectoral girdle and pelvic girdle. These elements are mostly exposed in ventral view, but the posterior dorsal parts, sacral parts and anterior caudal parts of the vertebral columns are in right lateral view. Most parts of the limbs, the anterior cervical vertebrae and the posterior caudal vertebrae are missing. The axial skeleton of the paratype is incomplete, about 120 cm long with the articulated cervical, dorsal and anterior sacral region of the vertebral column exposed in ventral view. All the limbs, the pectoral girdle and the pelvic girdle are missing. It suffered extreme dorsoventral compression.

Description The skull of V 14294 is well preserved in articulation with the incomplete lower jaw only on its left posterior margin. After preparation, the entire skull was extracted from the matrix rendering the examination of morphological detail in dorsal and ventral views of the rostrum possible and permitting the establishment of an exact tooth count on the premaxillae and maxillae (Fig. 1).

The new species is a middle sized *Nothosaurus*. The skull of the holotype (V 14294) is 210 mm in length (from the tip of the snout to occipital condyle) and the paratype (V 14301) is 320 mm (Table 1). The premaxillary rostrum is relatively small, with a length slightly larger than its width. The distance from the tip of the snout to the anterior margin of external naris is about 15% of the condylobasal length of the skull. The maximal width of rostrum is about 37% of the postorbital region in V 14294, and only 29% in V 14301. It shows blunt anterior, parallel lateral edges, and is set off by a well developed rostral constriction.

Each premaxilla carries a total of five teeth. They are recurved conical teeth and bear longitudinal ridges on their surface. The 5th is distinctly smaller than the preceding ones. The premaxillary dentitions of V 14294 are well preserved. Only the 5th left premaxillary tooth is lost. Among the preceding four fangs, the first one is somewhat shorter than the others and points obliquely downward. The right 3rd, the left 2nd, and 4th are robust fangs of approximately equal length, pointing downward and recurved. The right 2nd, 4th and the left 3rd are short and slender, procumbent and pointing obliquely downward.

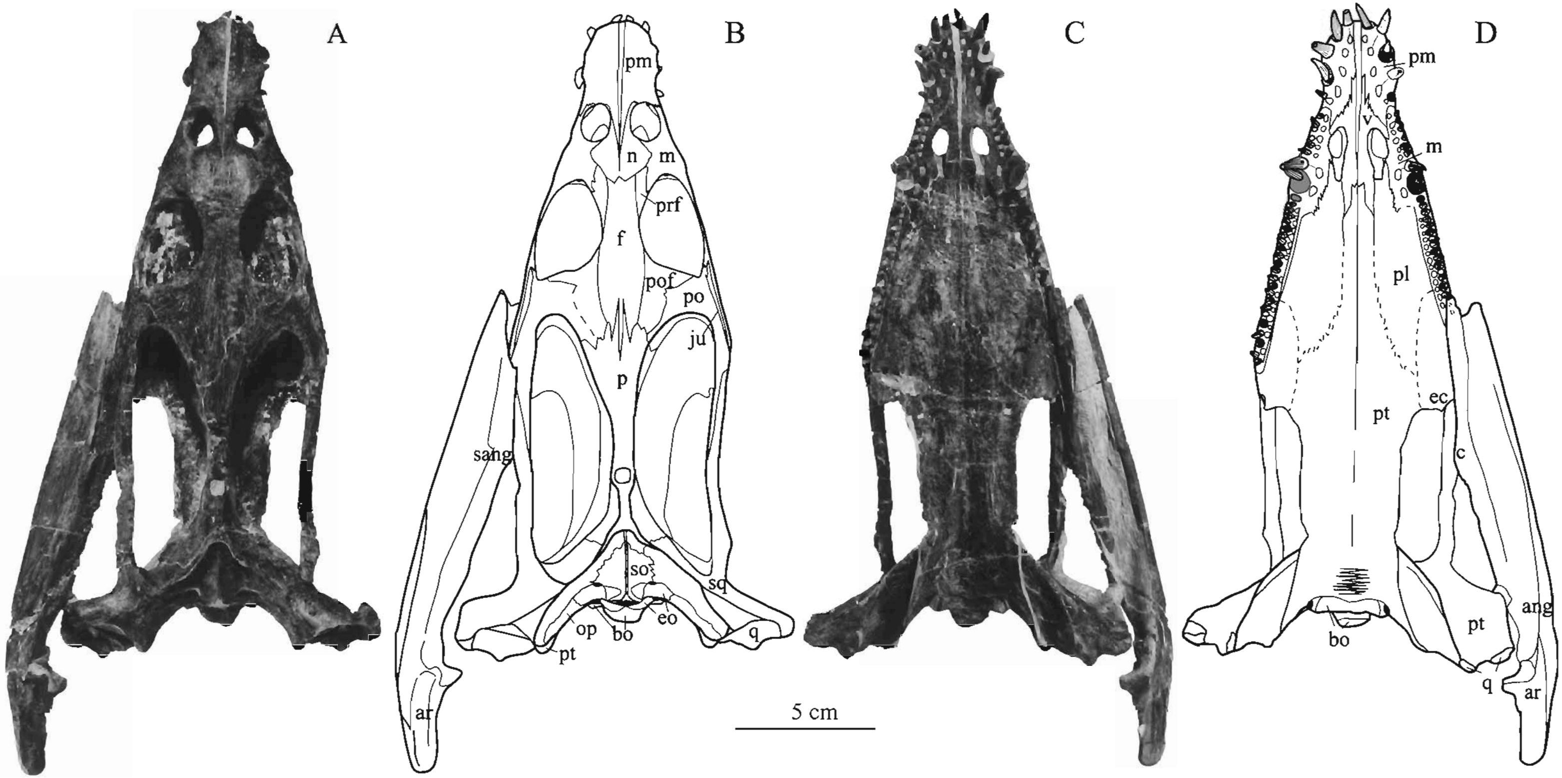


Fig. 1 The skull of *Nothosaurus rostellatus* sp. nov. (holotype, IVPP V 14294)
A. skull in dorsal view; B. reconstruction of skull in dorsal view; C. skull in vertral view; D. reconstruction of skull in vertral view
Abbreviations: ang. angular; ar. articular; bo. basioccipital; c. coronoid; ec. ectopterygoid; eo. exoccipital; f. frontal; ju. jugal; m. maxilla; n. nasal; op. opisthotic; p. parietal; pl. palatine; pm. premaxilla; po. postorbital; pof. postfrontal; prf. prefrontal; pt. pterygoid; q. quatrate; sang. surangular; so. supraoccipital; sq. squamosal; v. vomer

Table 1 Measurements for the skulls of IVPP V 14294 and IVPP V 14301* (mm)

	V 14294	V 14301
skull length from the tip of the snout to occipital condyle	210	320
length from the tip of the snout to anterior margin of external naris	31	50
length from the tip of the snout to anterior margin of orbit	60	100
length from the tip of the snout to anterior margin of upper temporal fossa	105	170
length from posterior margin of external naris to anterior margin of orbit	16	27
length from posterior margin of orbit to anterior margin of supratemporal fenestra	12	25
size of external naris (length × width)	16×12 (16×12)	25×17 (25×18)
size of internal naris (length × width)	18×7 (17×7)	30×13 (30×12)
size of orbit (length × width)	38×24 (38×24)	48×33 (47×34)
size of supratemporal fenestra (length × width)	85×28	120×45 (130×40)
size of pineal foramen (length × width)	6×5	—
maximal width of skull at:		
rostrum	26	37
rostral constriction	24	34
postorbital region	71	127
posterior end of squamosal	104	176
minimal width of bony bridge between:		
external nares	6	10
internal nares	7	8
orbits	12	25
upper temporal fossae	6	14

* Values in parentheses refer to the right side of the skull.

The external naris is elliptical. Its anterolateral margin is flat and restricted by the maxilla. The orbit is large and broad, and positioned relatively forward on the skull. The preorbital region of the skull is merely 30% of the condylobasal length; it is the most anterior position of the orbit observed within the *Nothosaurus* (Table 2). The length of the supratemporal fossa is more than twice of the orbital length.

The premaxilla forms the rostrum. It contacts the maxilla at the anterolateral corner of the external naris and makes a smaller process which trends posterolaterally to the level of the 2nd maxillary tooth. The dorsal process of the premaxilla extends backward between the external nares to meet the nasal behind the level of the posterior margin of the external naris. Its surface is sculptured with small and scattered pits.

The nasals meet each other along the midline of the skull and separate the dorsal process of the premaxilla from the frontal. A slender anteromedial process of the nasal lines the entire medial margin of the external naris, but the nasal did not take part in the formation of the posterior margin of the external naris. A small anteromedial process of the frontal extends between the tapered posterior tips of the two nasals. The surface of the bone is decorated with a scattered radiating pattern of grooves and ridges.

The frontal is an elongated element. It contacts the nasal anteriorly, at about the level of the anterior margin of the orbit, the prefrontal antero-laterally and the postfrontal postero-laterally. Posteriorly, the frontal meets the parietal in an interdigitating suture at the level of the posterior tip of the postfrontal within the anterior third of the longitudinal diameter of the upper temporal fossa. The prefrontal is usually a small element located at the anteromedial corner of the orbit, contacting the nasal and separating the frontal from the maxilla.

The postfrontal broadly lines the posterior and posteromedial margin of the orbit. It contacts the postorbital laterally, and shows a distinct constriction in the middle part of its lateral margin. It tapers posteriorly and contacts the parietal at a level behind the anterior end of the upper

temporal fossa.

The parietal is unpaired. It meets the frontal anteriorly, the postfrontal and postorbital antero-laterally. Anteriorly, the parietal is broad, but gradually narrows posteriorly. Posteriorly, the parietal skull table is strongly constricted but does not form a sagittal crest. The pineal foramen is an oval opening, situated near the position 2/3 of the length of the parietal.

The maxilla carries a slender anterior process which extends along most of the lateral margin of the external naris. Between the external naris and the orbit, the maxilla expands medially, thus defining the posterior margin of the external naris and the anterior margin of the orbit. The lacrimal foramen is well exposed, located in the anterior wall of the orbit within the maxilla. More posteriorly, the maxilla forms the entire lateral margin of the orbit and extends as a slender strip of bone along the lateral margin of the temporal arch up to a level behind the anterior margin, but in front of 1/5 length of the upper temporal fossa. The length of the maxillary tooth row, which extends to the level of temporal arch, is longer than in *N. youngi* and shorter than in *N. marchicus*.

Due to the good preservation, an exact tooth count could be established for maxillae. Paired enlarged maxillary fangs are situated at the level between the external naris and the orbit. There are six precanine maxillary teeth in the holotype. The paratype shows nine teeth preceding the paired maxillary fangs. These are distinctly smaller, conical teeth with longitudinal ridges on the surface and slightly recurved. There are 23 postcanine maxillary tooth positions on the left maxilla of the holotype. The posterior part of the left maxillary dentition is obscured by the lower jaw. Only 15 postcanine maxillary teeth are observed. The size and features of these teeth are nearly constant. They are 3 ~ 4 mm high, slightly shorter than the precanine maxillary teeth, and conical with longitudinal ridges on the surface also.

The postorbital shows a narrow entry into the posterior margin of the orbit at the posterolateral corner of the orbit, but a broad entry along the anterior margin of the upper temporal fossa. It contacts the maxilla antero-laterally and sutures with the jugal laterally. More posteriorly, the postorbital tapers to a slender process lining the lateral margin of the upper temporal fossa, sutured to the anterior process of the squamosal as it extends backwards beyond the level of the midpoint of the longitudinal diameter of the upper temporal fossa. The jugal is a slender bone intercalated between the maxilla and the postorbital. As in *N. jagisteus*, the widest part of the jugal is located somewhat anteriorly to the level of the posterior margin of the orbit, and its anterior end remains excluded from the margin of the orbit. Posteriorly, the jugal tapers gradually and ends at a level very near the posterior end of the maxilla, which is quite different from the situation in *N. jagisteus*. Behind the posterior tip of the jugal the contact between the postorbital and the maxilla is obscured.

The squamosal is a triradiate element. Its anterolateral ramus extends forward to contact the postorbital, and the antero-medial ramus is sutured to the parietal at the posteromedial margin of the upper temporal fossa. Posterolateral to the upper temporal fossa, the squamosal is drawn out into a distinct and elongate lateral ramus, which caps the cephalic condyle of the quadrate. Its occipital flange contacts the supraoccipital medially, the exoccipital and opisthotic ventrally. The lateral ramus of the parietal and the anterior medial ramus of the squamosal form a distinct occipital crest which separates the occipital surface from the dorsal surface of the skull.

The occiput is well preserved; this provides the possibility to delineate the contours and the relations of each occipital bone (Fig. 2). V 14294 shows the typical morphology of the braincase of *Nothosaurus* as was described by Rieppel (1994a), but with variation in some parts. The supraoccipital is an irregular element. Its surface is slightly inclined facing posterodorsally and it carries a distinct sagittal crest. Unlike other nothosaurs, the posterior region of the supraoccipital shows a distinct constriction, and then expands ventrally to form the dorsal margin

of the foramen magnum. Small but well defined posttemporal fossae are located in a deep recess at the posterolateral corners of the supraoccipital. They are bordered by the supraoccipital dorsally, the squamosal dorsolateally and the exoccipital ventrally and medially. The dorsal contour of the foramen magnum forms a rounded triangle, which is defined by the supraoccipital. The ventral contour of the foramen magnum forms a semicircle, which is defined by the exoccipitals laterally and the basioccipital ventrally.

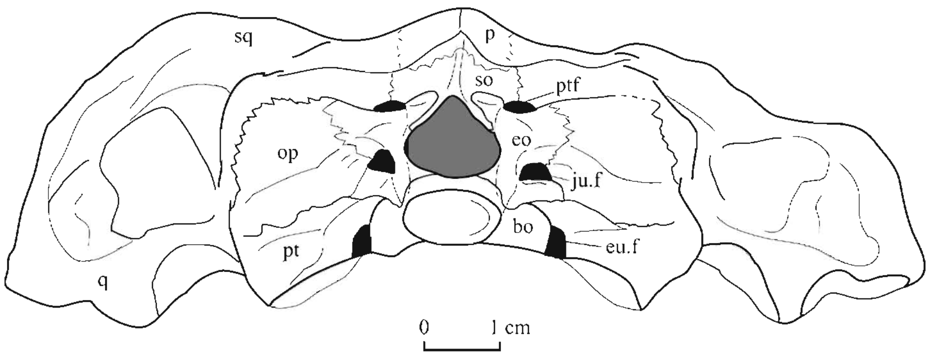


Fig. 2　The braincase of *Nothosaurus rostellatus* sp. nov. (holotype, IVPP V 14294) in posterior view
Abbreviations: bo. basioccipital; eo. exoccipital; eu. f. eustachian foramen; ju. f. jugular foramen; op. opisthotic; p. parietal; pt. pterygoid; ptf. posttemporal fossa; q. quatrate; so. supraoccipital; sq. squamosal

The occipital condyle points backward. Lateral to the occipital condyle, the basioccipital carries distinct basioccipital tubers. The two basioccipital tubers meet the pterygoid ventrally. Eustachian foramina open between the lateral margins of the basioccipital tubers and the pterygoids. The exoccipital is located at the dorsolateral corner of the foramen magnum. Medially, it defines the lateral margin of the foramen magnum, and shows a distinct extension inserted into the supraoccitial dorsomedially. Laterally, it shows dorsal and ventral extensions. The dorsolateral extension sutures with the supraoccipital dorsally and with the opisthotic laterally; it defines the dorsal margin of the metotic foramen. The ventral lateral extension sutures to the basioccipital tuber and pterygoid ventrally and to the opisthotic laterally; it defines the ventral margin of the metotic (jugular) foramen. As in other *Nothosaurus* (Rieppel, 1994a), the exoccipital does not completely enclose the metotic foramen, which is closed by the opisthotic laterally.

The opisthotic is broad and located laterally to the exoccipital. Unlike in *N. marchicus* (Rieppel and Wild, 1996) and *N. juvenilis* (Rieppel, 1994b), the opisthotic remains excluded from the posttemporal fossa. But as in *N. marchicus* and *N. juvenilis*, the paroccipital processes trend posterolaterally, which results in a distinct posterior displacement of the lower jaw articulation to a level well behind the occipital condyle. The occiput is deeply concave. Posterolateral to the occiput is a clear exposure of the quadrate. It has two distal condyles, the lateral one being larger than the medial one and in a rather high position.

In ventral view, the premaxilla meets the vomer in an interdigitated suture posteromedially, and contacts the maxilla posterolaterally. Its ventral posterior process lies between the vomer and the maxilla and extends backward approaching the anterolateral margin of the internal naris. The internal naris is elongate and oval, and it is bordered by the vomer, maxilla and palatine. Likes in *N. juvenilis*, the posterior margin of the internal naris delimits a deep choanal groove on the palatine. The vomer defines the entire anterior and medial margin of the internal naris. The anterior processes of the vomer enter deeply between the premaxillae. At the anterolateral corner of

the internal naris, the vomer establishes a very narrow contact with the maxilla, apparently excluding the premaxilla from the anterolateral margin of the internal naris. Posteriorly, it meets the palatine in the posterior margin of the choana laterally, the pterygoid medially.

The palatine is an elongate element that is situated between the maxilla and pterygoid. Its narrow anterior end defines the posterior margin of the internal naris. Anterolaterally, the palatine contacts the maxilla in a deeply interdigitated suture; laterally, it contacts the maxilla in a smooth suture that parallels the dentary row. The contacts of the ectopterygoid with the palatine and pterygoid are obscure. However, some important details of the ectopterygoid are still discernible. It forms the anterolateral margin of the subtemporal fossa, and develops a distinct ventral projection at the anterolateral corner of the latter.

The pterygoids are large and elongate elements. Anteriorly, they form long palatal processes which enter between the palatines and the vomers into the level approaching the posterior margin of the internal naris (choanal groove). Laterally they contact the palatines and the ectopterygoids. The quadrate ramus of the pterygoid diverges posterolaterally to meet the quadrate, medially it sutures with the basioccipital and the exoccipital in occipital surface.

The lower jaws are mostly lost with only the posterior part of left lower jaw being preserved. The coronoid is located on the medial side of the suprangular. It forms a distinct coronoid process, as is the case in *N. youngi*. The angular is elongate and forms the ventral aspect of the posterior lower jaw, which extends backward up to the posterior end of the lower jaw. The jaw articulation is formed by the angular in its lateral part, and by the articular in its medial part. The retroarticular process is elongate.

The vertebral column of V 14294 is represented by a total of 38 vertebrae in articulation, of which most cervical vertebrae and some caudal vertebrae are missing, whereas the dorsal vertebrae and the sacral vertebrae are completely preserved (Fig. 3).

Due to the preservation of the skeleton, the boundary between the cervical vertebrae and dorsal vertebrae cannot be established unequivocally. However, based on the normal position of the pectoral girdle, the vertebra located close to the clavicle is here interpreted as the first dorsal vertebra. Only three posterior cervical vertebrae are exposed, two are articulated with the dorsal vertebra and show their ventral surfaces, one is scattered alongside the former and mostly buried by matrix. The centra of the cervical vertebrae are platycoelous, longer than wide, without a distinct ventral ridge. The parapophysis is located on the basal part of the centrum; it is 2 mm long, 5 mm wide. One cervical rib is scattered near the cervical vertebra. It is small (12 mm long) and formed as elongated triangular shape.

A total of 24 dorsal vertebrae are reconstructed. Among them, 5 centra are dissociated from their neural arches, indicating that the neurocentral suture remained unfused. The anterior 16 vertebrae are exposed in ventral view, the more posterior elements are exposed in right lateral view.

The first dorsal vertebra shows a well-developed parapophysis, which is located on the centrum. The second dorsal vertebra is represented by the dissociated neural arch. Its cruciform sutural facet shows a very different contour than more posterior vertebrae, for its margin is transversely extended as tongue-shaped. This sutural facet feature indicates that the neural arch participates in the forming of the parapophysis. The third dorsal vertebra shows the fusion of the parapophysis and dispophysis, with the neurocentral suture traversing the synapophysis. The fourth dorsal vertebra appears to carry a transverse process that originats from the neural arch only, while the parapophysis on the centrum disappeared. More posteriorly the position of the transverse processes gradually moves upwards on the neural arches. The disappearance of the parapophysis on the centrum had been considered as the main characteristics that distinguishes dorsal and cervical vertebra in *N. jagisteus* (Rieppel, 2001). The specimen V 14294 shows the parapophysis is still developed in the anterior dorsal vertebrae centra.



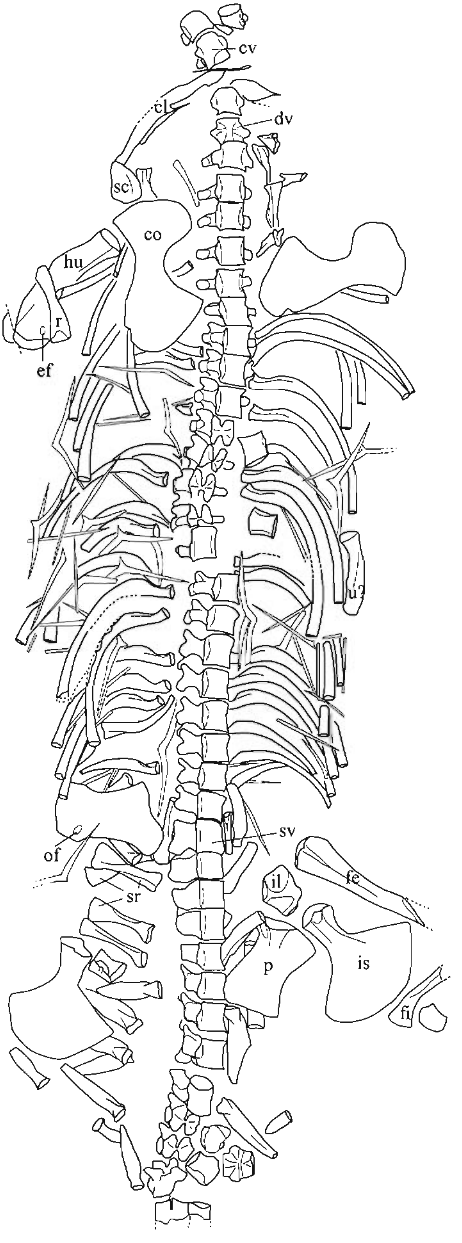


Fig. 3 The axial skeleton of *Nothosaurus rostellatus* sp. nov. (holotype, IVPP V 14294)
Abbreviations: cl. clavicle; co. coracoid; cv. cervical vertebra; dv. dorsal vertebra; ef. entepicondylar foramen; fe. femur; fi. fibula; hu. humerus; il. ilium; is. ischium; of. obturator foramen; p. pubis; r. radius; sc. scapula; sr. sacral rib; sv. sacral vertebra; u. ulna

The centra of the dorsal vertebrae are platycoelous too, with a slightly constricted body, which is longer than wide (18 mm × 16 mm). The neural arch is broader and the neural spine is low. Measured from the broken 16th dorsal vertebra, the neural spine (from the dorsal surface

of the transverse process up to its dorsal margin) is about 5 mm high; the neural arch (across the transverse processes) is 35 mm wide. The low neural spine characteristic of the specimen is similar to *N. marchiucus* and *N. giganteus* (Rieppel and Wild, 1996), and also resembles *Sanchiaosaurus dengi* (Young, 1965). However unlike *N. giganteus*, the strong transverse processes extend down all along the pedicels of the neural arch and did not take part to form the neurocentral suture, except for the anterior four dorsal vertabrae. This can be observed from the dissociated $12^{th} \sim 15^{th}$ dorsal vertebral sutural facets, for the lateral contours of these sutural facets are slightly curved and without transverse extension (to compare with the sutural facet of the second dorsal vertebra). The pre- and postzygapophyses are broader. More posteriorly the transverse processes shorten gradually.

The dorsal rib is unicipital. Its articular head is oblong in dorsoventral direction and articulates on stout transverse process. It projects laterally with a distinct constriction at its basal part and then expands, which results in a broadened curved "shoulder" part; the shaft turns narrow gradually, but is moderately expanded distally. The widest "shoulder" part of rib is 10 mm wide in V 14294 and 15 mm wide in V 14301. There are distinct longitudinal grooves developed on the anterior surface of the dorsal ribs, which disappear within the "shoulder" part. More than 18 dorsal ribs can be observed on each side of the vertebral column in V 14294. The dorsal ribs associated with anterior parts of the dorsal vertebra 1 column are about 13 cm long, more posteriorly the ribs are 12 cm long (measured along its curvature).

Very slender disarticulated gastral rib elements are scattered across the dorsal ribs. The ventromedial elements of gastral rib carry a distinct narrow and spiny anterior projection that is about 5 mm long, and their lateral shanks enclose a wide angle about 140°. The needle shaped element that is articulated on either side of the ventromedial element is 45 mm wide.

There is no clear separation of the dorsal and sacral vertebrae. Although some sacral vertebrae show relatively broader articular facets, the exactly number of them is difficult to ascertain. Three or four ribs may possible be identified as sacrals on the right side of the vertebral column. These are relatively long elements, with slightly widened distal end, and they are about 45 mm long. The sacral ribs on the left side are mostly concealed by the matrix.

There are more than 9 caudal vertebrae preserved, exposed mostly in right lateral views. The last preserved caudal vertebra is extremely broken but shows the apparent characteristic of the neural spine. The neural spine of the caudal vertebra is low and flat, about 5 mm high and 10 mm long. The scattered caudal ribs are of different length. The ribs on the anterior portion of the tail are relatively long, expanded in their middle region and tapering towards their distal ends and the first caudal rib is nearly as stout as the preceding sacral rib.

The pectoral girdle in V 14294 is incompletely preserved. The clavicle is broken and the interclavicle lost. Only the fattened ventral surface of the lower part of the right scapula is exposed. However, the coracoids are well-preserved, with the typically nothosaurian structure and shape. The coracoid shows a broad lateral expansion which contacts the glenoid portion of the scapula. Its middle portion is distinctly constricted and the medial part expanding again. Unlike in *N. youngi* (Li and Rieppel, 2004), *N. jagisteus* and *N.* cf. *N. mirabilis* (Rieppel, 2001), the coracoid foramen is represented by a shallow notch in the posterior part of the coracoid proximal margin. Measurements of the coracoids of V 14294 show that its maximum length is 102 mm (left), 101 mm (right), its proximal width is 56 mm (left), 55 mm (right), its distal width is 52 mm (left), 53mm (right), its middle constriction width is 19 mm. Comparison with the size of the coracoids in *N. jagisteus* (Rieppel, 2001) shows that V 14294 has relatively more slender coracoids than the latter species.

The pelvic girdle is mostly preserved but not in normal position. It resembles that of other nothosaurs in contour (Romer, 1956, fig. 158 C). The ilium is roughly polygonal, small, with the glenoid portion exposed in different directions. The pubis is a large, plate-like element,

with slightly constricted anterior and posterior margins, and a distinct obturator foramen. Its maximum length is 70 mm (left), the proximal width is 41 mm (left), the distal width is 50 mm (left), and the minimal middle width is 75 mm. The ischium has a narrow and thickened proximal end contacting the ilium, waisted in the middle, from which it expands to form a flattened ventral plate. Its maximum length is 75 mm (left), 76 mm (right), its proximal width is 26 mm (left), its distal width is 84 mm (left), and its minimal middle width is 22 mm.

Only the right humerus, right radius and left ulna of the forelimb are preserved. The right humerus is exposed in ventral view and articulates with the right scapulocoracoid. It has a thick shaft and a curved appearance. The length of the postaxial margin is 90 mm; the preaxial margin is 80 mm. Its proximal end expands in a dorsalventral direction, without distinct deltopectoral crest. The distal end is moderately flattened, as that of other nothosaurs, the ectepicondylar groove is distinct, and the entepicondylar foramen is present as well. The right radius is slender, with a straight postaxial and a curved preaxial margin. Its maximum length is 52 mm, its proximal width is 14 mm, and its minimal middle width is 8 mm. The left ulna is exposed within scattered ribs. It is dorsoventrally flattened and distinctly broader than the radius. The postaxial margin of the ulna is less concave than its preaxial margin. The postaxial margin is 50 mm long, and the preaxial margin is 42 mm long.

Of the hind limb only the incomplete left femur and left fibula are preserved. The femur is slightly thinner and longer than the humerus, with a distinctly expanded proximal end. The exact length of the femur cannot be measured, because the distal part is missing. The fibula is thin, with a dorsoventrally flattened distal end. Its proximal end is missing.

Discussion The proportion of the snout was the most conspicuous diagnostic feature of the new species. As discussed above, the new species has a short and small rostrum. It is set off from the remaining skull by a distinct rostral constriction. Although the new species is morphologically intermediate between *N. marchicus* and *N. youngi*, the rostrum length (distance from the tip of the snout to the anterior margin of the external naris) of the new species is much shorter in proportion to the condylobasal skull length (Fig. 4). The measurement and calculation of the ratio of the condylobasal skull length to the rostrum length of all species of *Nothosaurus* (see Table 2, column 1), show the length of the rostrum to be less than 1/6 of the skull in the new species (data based on the holotype V 14294 and the paratype V 14301), to be more than 1/6 in other species. In *N. haasi* that has a long and slender rostrum, the ratio is 1/3. In addition, the ratio of the distance from the tip of the snout to the anterior margin of the upper temporal fenestra to the rostrum length (distance from the tip of the snout to the anterior margin of the external naris) also yields high values in the holotype and paratype by comparison to other species (see Table 2, column 2). This value again suggests the relatively short snout in the new species. As mentioned by Rieppel (2000), the relative rostrum proportions vary between species, and are of taxonomic importance.

The second distinct diagnostic feature is the number and arrangement of the maxillary teeth. As one of the typical character of *Nothosaurus* the maxilla carries paired fangs that are preceded by three to six smaller teeth (Rieppel, 2000). However most species of *Nothosaurus* have been described with no more than five precanine maxillary teeth. Specimen V 14294 has six small conical maxillary teeth preceding the paired fangs, and specimen V 14301 carries nine teeth in that position.

Associated with the shorter rostrum the position of the orbit is relatively anterior on the skull. Compared to the other species of *Nothosaurus*, the ratios of the skull length to the preorbital length (distance from the tip of the snout to the anterior margin of the orbit) show the highest value in the new species (see Table 2, column 3). On the other hand, the ratio between the length and width of the rostrum (see Table 2, column 4) shows that the new species shares the plesiomorphic character with *N. marchicus*, *N. youngi* and *N. edingerae*, all of

which have a relatively short and broad rostrum. The ratio of the pre-orbital length to the rostrum length of V 14294 and V 14301 also show equal value with them (see Table 2, column 5). These data further confirmed the forward position of the orbit of the new species, because it keeps a smaller rostrum.

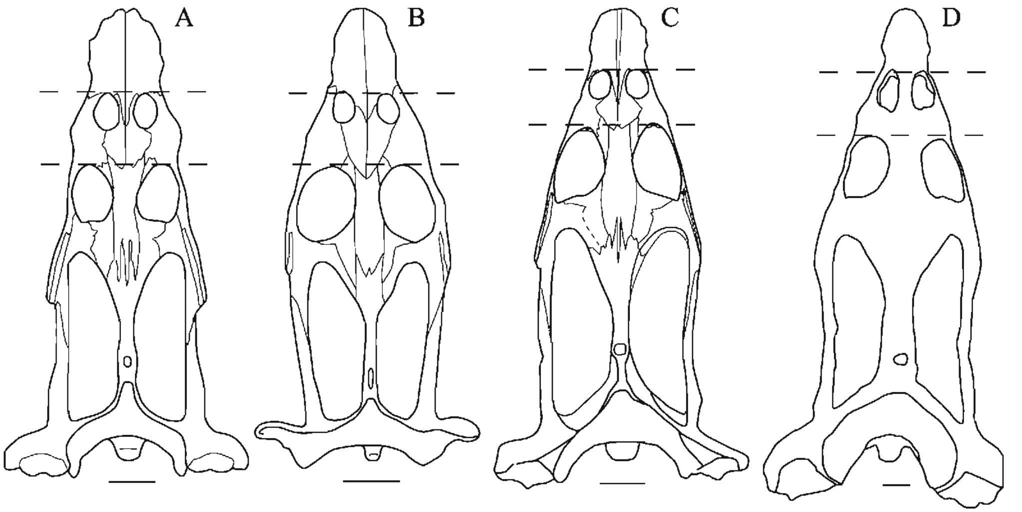


Fig. 4 The proportional relations of four reconstructed nothosaur skulls, in dorsal view
A. *N. marchicus*, based on Rieppel, 2000, p. 82, fig. 60; B. *N. youngi*, based on Li and Rieppel, 2004, p. 4, fig. 2; C. IVPP V 14294; D. IVPP V 14301; scale bars = 20 mm

Table 2 Cranial proportions in the species of the genus *Nothosaurus*

	1*	2	3*	4	5	6	7	8
IVPP V 14294	6.8	3.65	3.5	1.3	1.93	2.47	1.37	2.24
IVPP V 14301	6.4	3.4	3.2	1.47	2.0	2.66	1.47	2.5
N. marchicus [1)]	5.3~6.0	2.9~3.4	2.9~3.1	1.1~1.4	1.8~2.0	2.6~3.0	1.0~1.4	2.1~3.0
N. youngi [2)]	5.52	3.0	2.90	1.4	1.9	2.9	1.5	2.0
N. jagisteus [1)]	4.33	2.41	2.77	1.98	1.55	2.69	1.79	2.8
N. edingerae [1)]	4.5	2.88	2.7	1.3	1.88	2.58	1.85	2.43
N. juvenilis [1)]	4.7	2.74	2.6	1.55	1.74	3.08	1.37	1.58
N. haasi [3)]	3.1	2.04	2.0	2.62	1.5	—	2.56	—
N. tchernovi [3)]	4.5	2.45	2.6	2.0	1.59	—	1.56	—
N. giganteus [1)]	5.46	2.6~3.4	2.9	1.2~1.6	1.6~2	2.42	1.7~1.8	3.67
N. mirabilis [1)]	4.4	2.2~2.7	2.6	1.5~2.5	1.5~1.7	2.3~2.5	1.6~2.2	2.9~3.8

Ratios: 1. condylobasal skull length divided by distance from tip of snout to anterior margin of external naris; 2. distance from tip of snout to anterior margin of the upper temporal fenestra divided by the distance from tip of snout to anterior margin of external naris; 3. condylobasal skull length divided by distance from tip of snout to anterior margin of orbit; 4. distance from the tip of snout to the anterior margin of the external naris divided by width of the skull at the rostral constriction; 5. distance from tip of snout to the anterior margin of orbit divided by distance from tip of snout to anterior margin of external naris; 6. condylobasal skull length divided by longitudinal diameter of the upper temporal fenestra; 7. longitudinal diameter of the external naris divided by its transverse diameter; 8. longitudinal diameter of the upper temporal fenestra divided by longitudinal diameter of the orbit; * The data of columns 1 and 3 come from the recalculation of Rieppel, 1994b, 2000, 2001; Rieppel and Wild, 1996; Rieppel et al., 1999, except for IVPP V 14294 and V 14301; 1) The data mostly derived from Rieppel (2001); 2) from Li and Rieppel (2004); 3) from Rieppel et al. (1999).

Furthermore, the new species is also characterized by the intermediate posterior extent of the maxillary tooth row, the relatively longer jugal, the development of the choanal groove, the

particular shape of the supraoccipital and basioccipital, the deeply concave occiput, the low neural spines, and the pachyostosis of the dorsal rib "shoulder". Indeed, the specimens V 14294 and V 14301 show a number of autapomorphies by comparison to all other species of *Nothosaurus*, which diagnose the specimens as representatives of a new species. The holotype of V 14294 represents a relatively juvenile individual, whereas the paratype of V 14301 is of an adult individual.

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